MARS PATHFINDER PROJECT PROGRESS REPORT

Anthony J. Spear
Mars Pathfinder Project Manager
Matthew]'. Golombek
Mars Pathfinder Project Scientist
Jet Propulsion Laboratory
California Institute Technology
4800 Oak Grove Drive, M/S 230-235
Pasadena, California 91109-8099
'l'el: 818-393-7868/7948 Fax: 393-1227
ii-Mail: anthony.j.spear@jpl.nasa.gov
mgolombek@jpl.nasa.gov

Abstract

Mars Pathfinder is the second of NASA's "cheaper, better, faster''l)iscovery missions; the first, the Near Earth Asteroid Rendezvous mission, was launched February 17, 1996 to tag up with Eros in February 1999. Launching on December 2, 1996 and landing on Mars on July 4, 1997, Pathfinder will demonstrate a low-cost delivery system to the surface of Mars. Historically, spacecraft that orbit or land on a distant body carry a massive amount of fuel for braking at the planet. Pathfinder requires fuel only to navigate to Mars; the spacecraft aerobrakes into the. Mars atmosphere directly from Earth-Mars transfer trajectory, deploys a parachute at 10 km above the surface and, within 100 m of the surface, fires solid rockets for final braking prior 10 deployment of airbags that cushion touchdown. After landing, petals open to upright the lander, followed by deployment of a small rover and several science instruments.

A major objective of Pathfinder- acquisition and return of engineering data on entry, descent, and landing (EDL) and lander performance- -will be completed within the first few hours after landing. In addition, the lander will transmit images of the Martian surface the first clay. Next, a rover will be deployed, as early as the first day, to perform mobility tests, image its surroundings, including the lander, and place an alpha proton x-ray spectrometer (APXS) against a rock or soil to make elemental composition measurements. The primary mission durations for the rover and lander are one week and one month, respectively. However, there is nothing to preclude longer operations up to a year.

Pathfinder will also accomplish a focused, exciting set of science investigations with a stereo, multi-color lander imager on a pop-up mast; atmospheric instrumentation for measuring a pressure, temperature and density profile during entry and descent and for monitoring martian weather after landing; and the rover with its forward and aft cameras and the APXS. The APXS and the visible to near infrared filters on the lander imaging system will determine the elemental composition and constrain the mineralogy of rocks and other surface materials, which can be used to address first order questions concerning the composition of the crust, its differentiation and the development of weathering products. Regular tracking of the lander will allow determination of the martian po]c of rotation, its precession since Viking era measurements, and the moment of inertia, which should allow discrimination between interior models that include a metallic core and those that do not.

The Pathfinder Landing Site selected is Arcs Vallis (19.5°N, 32.8°W), which is near the sub-solar latitude (15"N) for maximum solar power at landing on July 4, 1997 and is at 2 km below the datum for correct operation of the parachute. The site is in Chryse Plan it ia a lowland where a number of catastrophic floods from the highlands to the north debouch. It is a "grab bag" site with the potential for sampling a wide variety of different martian crustal materials, such as ancient crustal materials, intermediate age ridged plains and a variety of reworked channel materials. Even though the exact provenance of the samples would not be known, data from subsequent orbital remote sensing missions could be used to infer the provenance for the "ground truth" samples studied by Pathfinder. Available data suggest the site is about as rocky as the Viking sites, but perhaps a bit less dusty. This site has streamlined islands nearby, carved by the. flood, and a very smooth depositional surface at Viking resolution, except for small hills and secondary craters.

This paper reports on the status of Mars Pathfinder's drive to space qualify its Flight System for launch on December 2, 1996 under a cost cap -in particular how the Project is dealing with qualification of its entry, dc.scent and landing event and the surface operations phase as well as the normal launch and space flight phases. It also reports on its landing site selection and science plan.

MARS PATHFINDER SCIENCE OBJECTIVES AND INVESTIGATIONS

The scientific objectives and investigations addressable by the Pathfinder payload include: surface morphology and geology at meter scale, elemental composition and mineralogy of surface materials and a variety of atmospheric science investigations.

The surface imaging system will reveal martian geologic processes and surface-atmosphere interactions at a scale currently known only at the two Viking landing sites. It will observe the rock distribution, surface slopes and general physiography in order to understand the geological processes that created the surface. This will be accomplished by panoramic stereo imaging at various times of the day as well as before and after the imager deploys on its pop-up mast. In addition, observations over the life of the mission will allow assessment of any changes in the scene over time that might be attributable to frost, dust or sand deposition or erosion or other surface-atmosphere interactions. The rover will also take close-up images of the terrain during its traverses. A basic understanding of near-surface stratigraphy and soil mechanics will be obtained by imaging from both rover and lander, rover tracks, holes dug by rover wheels, and any surface depressions left by the retraction of the airbags or the landing of the spacecraft.

The APXS and the visible to near infrared (0.4 to 1 micron) spectral filters on the imaging system will determine the elemental composition and constrain the mineralogy (IMP filters are particularly sensitive to pyroxene and iron oxides) of rocks and other surface materials, which can be used to address questions concerning the composition of the crust, its differentiation and the development of weathering products. These investigations will represent a calibration point ("ground truth") for orbital remote sensing observations. The imaging system will obtain full multispectral panoramas of the surface and any subsurface layers exposed by the rover and lander. Because the APXS is mounted on the rover it will characterize the composition of rocks and soil in the vicinity of the lander (tens of meters), which will represent a significant improvement in our knowledge over that obtained by Viking or that likely to be obtained by the Russian Mars 96 small stations, which deploy the APXS on single degree of freedom arms. The rover-mounted APXS sensor head on Pathfinder will also be placed in holes dug by the rover wheels and against rocks that have been abraded by a rover wheel. Multispectral images are also planned for 2 sets of magnetic targets distributed at two locations (and heights) on the spacecraft that will discriminate the magnetic phase of accumulated airborne dust. In addition, a single magnetic target mounted near the imager head will be viewed by a magnifying lens to determine the size and shape of individual magnetic particles. The APXS will also measure the composition and, in particular, the titanium content of dust adhering to magnetic targets at the end of the rover ramps, which is critical for discriminating the various magnetic phases. A rear-facing imager will enable close-up images with millimeter resolution of every APXS measurement site. Between these images and auxiliary information from lander imaging spectra, it is likely that mineralogy can be constrained from the elemental abundances measured by the APXS.

The atmospheric structure instrument will determine a pressure, temperature and density profile of the atmosphere with respect to altitude during entry and descent at a new location, time and season. Measurements of pressure and temperature will be made in a triangular space between the petals at the base of the lander during descent. Redundant three-axis accelerometers will allow extraction of atmospheric density profiles and hence pressure and temperature profiles during entry. Diurnal variations in the atmospheric boundary layer will be characterized by regular surface meteorology measurements (pressure, temperature, atmospheric opacity, and wind). Three thermocouples mounted on a meter high mast located on a petal away from the thermally contaminating lander electronics will determine the ambient temperature profile with altitude (one thermocouple on top, one at the mid point and the third one quarter from the bottom). A wind sensor on the top of this mast along with 3 wind socks below it will allow determination of wind speed and direction versus altitude in the boundary layer as well as calculation of the aerodynamic roughness of the surface. Regular sky and solar spectral observations by the lander imager will also monitor dust particle size and shape, refractive index, vertical aerosol distribution and water vapor abundance.

By 2-way range and Doppler tracking of the Mars Pathfinder lander during communication sessions a variety of orbital and rotational dynamics science objectives can be addressed. Within a few months of such tracking, it is expected that the location of the Pathfinder lander can be determined to within a couple of meters. With the location of the lander known, the pole of rotation of the planet can also be determined. Knowledge of the orientation of the pole of rotation allows calculation of the precession constant to a fraction of a percent by comparing with similar measurements made with the Viking landers about 20 years ago. Measurement of the precession constant (regular motion of the pole with respect to the ecliptic) allows direct calculation of the moment of inertia, which is governed by the density distribution with depth of the planet. At present, the moment of inertia of Mars is poorly known and allows interior models with and without a metallic core. This measurement of the moment of inertia will provide strong constraints on possible interior models and likely distinguish between these competing interior models. The present day moment of inertia is also a strong constraint on potential obliquity variations in the past, which could have been large for Mars. Constraining possible obliquity variations is important for understanding the long term climatic fluctuations. The seasonal variations in rotation rate (changes in

Atmospheric Structure instrument / Meteorology Package (ASI/MET)

The ASI/MET is implemented as a facility instrument, developed by J]'],, to provide engineering support to the measurement of the entry descent and landing conditions and to acquire science data both before and after landing. Data acquired during the entry and descent of the lander permits the reconstruction of profiles of atmospheric density, temperature and pressure from altitudes in excess of 100 km to the surface. The accelerometer portion of the experiment consists of redundant x-, y- and z-axis sensors. Three gain states are provided to cover the wide dynamic range from the micro-g accelerations experienced upon entering the atmosphere to the peak deceleration experienced during entry into the atmosphere.

The ASI/MET instrument hardware consists of 4 thermocouples and a wind sensor mounted on a 1 meter long mast that deploys upright from the end of a lander petal after landing. A pressure sensor is mounted within the thermal enclosure of the lander with a tube leading to a triangular opening between the petals for measurement of the pressure during descent and after larding. Pressure and temperature sensors are sampled twice per second while entering and descending through the atmosphere. Temperature, pressure, wind speed and direction are sampled hourly throughout the landed mission at multiple heights above the local surface.

Rover Instruments

The rover payload consists of monochrome stereo forward cameras for hazard detection and terrain imaging and a single rear color camera, On the rear of the vehicle is the. alpha proton x-ray spectrometer mounted on a deployment device that enables placing the APXS sensor head up against both rocks and the soil at a wide variety of orientations. The rear facing camera will image the APXS measurement site with order 1 mm resolution.

The rove.r will also perform a number of technology experiments designed to provide information that will improve the design of future planetary rovers. These experiments include: terrain geometry reconstruction from latdcr/rover imagery; basic soil mechanics by imaging wheel tracks and wheel sinkage; dead reckoning sensor performance and path reconstruction/recovery; logging/trending of vehicle data; rover thermal characterization; rover vision sensor performance; UHF link effectiveness; material abrasion by sensing loss of coverings of different thickness on a rover wheel; and material adherence by measuring dust accumulation on a reference solar cell with a removable cover and by directly measuring the mass of the accumulated dust on a quartz crystal microbalance.

MARS PATHFINDER PROJECT APPROACH

Pathfinder is in a special "cheaper, better, faster" project operating mode, accomplishing a challenging mission on a quick reaction schedule, at low cost and fixed price, using a "Kelly Johnson" like skunkworks approach, with the majority of its team co-located within J]'], focusing on a limited set of objectives, cost-effectively balancing the use of available and new technology, exploiting J]']'s deep space infrastructure, streamlining project approaches and minimizing bureaucratic red tape. NASA's Office of Space Science is developing Pathfinder. The Advanced Concepts and Technology Office teamed with the Space Science office is developing the Pathfinder rover. Pathfinder is being performed at J]'], in its in-house, subsystem mode.

Project Challenges in Today's Environment

Projects under tight cost and schedule constraints must not take "short cuts" in certain critical project implementation steps, just the opposite, these steps must be emphasized even more.

Some. of these critical steps arc:

1. Technical, cost and schedule planning
2. Technical, cost and schedule monitoring and control
3. Risk assessment and mitigation

Risk has two elements: programmatic and mission which are highly interrelated. Over-emphasis on staying within the budget could jeopardize mission success, and in today's environment, it is not acceptable. to overrun cost caps.

in addition, with NASA's breaking up the available space $ pie into many small missions, avoiding all eggs in one basket, the.re is no excuse for taking undue programmatic or mission risk on any one small mission.

Then how does a project manager proceed with what appears to be a rather highly constrained project implementation challenge: accomplishing a significant mission, under tight cost and schedule constraints, while not failing?

First: At the outset, a mission scope doable. within the $ cap must be identified, firmed and maintained.

This is a non-trivial task since it requires significant up front mission planning, assessment of implementation, design and test challenges and thorough cost estimating. Iteration of mission scope may be necessary to achieve a sufficient $ reserves pool at the start of the project, correctly phased over the span of the development period. For Pathfinder, we started with a $100M mission scope with $50M in reserves (FY92 $).

Approaching launch, the majority of our $ reserves have been used, not for increased mission scope, this remained as originally specified, but to cover flight system implementation challenges largely in EDL design and test and in squeezing cruise, EDL, and surface operations functions into one spacecraft- our two major innovations on this project, both with large $ uncertainty at the outset. The rest of the project elements. project management, mission design, ground data system, mission operations development and instruments are being accomplished at our under their original cost caps.

Barring major difficulties in final flight system and environmental testing, we stand a good chance of completing development within the cost cap.

Second: Project monitoring and control methods must be established to assess performance so that effective necessary corrective action can be implemented quickly for problems.

With today's computers and management tools, the. challenge here lies with selection of a system and metrics that are useful to the project team at the same time providing clear representations of performance to Program and institutional managers of the Project.

But computer aided metrics, schedules, tables of cost in every format are only as good as the input, never ever will they be a substitute for a good team- which if necessary can still do a project on the back of an envelope.

First we assembled an excellent, motivated team. Now that may sound like "Motherhood and Apple Pie", but far and away this is the most important ingredient to Pathfinder's successful approach to date. Pulling high-spirited individuals together, inside and outside JPL, to make up the Pathfinder team was not an easy task. With JPL institutional support, key team members were extracted from their home divisions and co-located with the Project in what is called a "soft projectization mode" where team members remain administratively tied to their home divisions. The team is a mix of bright, ambitious youth and seamed old-timers, all sensitized not only to the technical challenge but very importantly to the need to do this job at a fixed price. All were empowered to produce their product according to their plan.

Not fully appreciated at the start was the degree to which we would need to expand the Pathfinder team outside of JPL in order to bring in the necessary expertise for development of our entry, descent and landing approach.

We knew we had to go outside of JPL for this, but never appreciated how much. You could not go to the JPL phone book and look up the names for the. planetary entry, descent and landing division. We have. not had this development expertise at JPL in place since the Surveyor Moon mission in the 1960s- as a matter of fact, no complete planetary landing development technology base was available anywhere in the US.

At Pathfinder start, just bits and pieces of related expertise were scattered about, We scoured the country side and found this support:

1. Major test facilities and test expertise for early proof-of-concept airbag testing at Sandia National Laboratories
2. Key aged, but contributing Viking engineers and managers and their lessons learned
3. Excellent, cost-effective atmospheric entry support from NASA's Ames and Langley Research Centers
4. Aeroshell design, fabrication and test expertise at Lockheed Martin adapting the Viking design including use of the Viking heatshield ablative material
5. Parachute experience at Pioneer Aerospace adapting mainly their Earth parachute expertise, but starting with the Viking disk-gap-band parachute design and importantly relying on Viking's extensive parachute test experience, especially at high altitudes
6. Extensive expertise at ILC Dover for Pathfinder's major development of the airbags
7. Major test facilities and test expertise at the China Lake Naval Weapons Center for rocket drop tests, altimeter tests and cruise stage-backshell- lander separations tests
8. Major test facilities and test expertise at NASA's Lewis Research Center Plum Brook Station chamber for airbag drop tests at simulated Mars atmosphere
9. Very importantly, the infusion into the Pathfinder team of a design-test-design-test some more --- culture for items like. the parachute, the. bridle, solid rocket system and the airbags by Sandia, Pioneer, China Lake and ILC Dover

10. Design and test consulting and critique from within JPL, Sandia, Space Industries, NASA's Ames and Langley Research Centers, Lockheed Martin and from numerous consultants (we also interacted with the Russians and the European Space Agency [ESA])

JPL is putting the whole EDL system together: performing the system design, orchestrating the EDL tests and simulations, assessing mission risk mitigation, and building the backshell, bridle and lander including its uprighting petals (as well as the cruise stage which is jettisoned prior to entry). The full EDL team is listed in Table 1. To a contractor, small to large, each got with the spirit of Pathfinder, doing more for less. Most contracts were fixed price.

Table 1: EDL SUPPORT TEAM

System	JPL
Red Hat Team[1]	JPL, USC, Space Industries, UCLA, CIT, Other consultants
Analysis, Consulting, Review	Space Industries
Entry Dynamics Sim	Langley Research Center
Backshell Structure	Lockheed Martin
Backshell Interface Plate (BIP)	JPL
Aeroshell and Heatshield Analysis	Lockheed Martin
Heatshield Analysis Support	Ames Research Center/Applied Research Associates/Langley Research Ctr.
Backshell TPS	Lockheed Martin
BIP Insulation	Ames Research Center
Multi-Body Descent Sim	JPL
Parachute	Pioneer Aerospace
Bridle Drop Tests	China Lake Naval Air Weapons Center
Bridle	JPL
RAD System	JPL
RAD Rockets	Thiokol
Airbag Impact Analysis	Sandia National Lab, Rockwell
Airbags	ILC Dover
Airbag Gas Generators	Thiokol
Separations	JPL
Sequence	JPL
Communications	JPL
RAD Drop Tests	China Lake Naval Air Weapons Center
Initial Airbag Drop Test	Sandia National Lab
Full-Scale Airbag Drop Tests	Lewis Plum Brook Research Center
Parachute Drop Tests	Yuma and Boise Orchard Training Range

What makes a good project team

A good project team relies on fundamentals: achieving a thorough understanding of the work scope, breaking this work scope into its individual pieces, assigning individual team members responsibility for these pieces, giving them a clear understanding of their responsibility and constraints, and doing the system engineering up front to ensure compatibility of the pieces.

A good project team is dynamic and flexible. It carries an up-to-date, thorough cost and schedule plan in front of it at all times, changing the plan as necessary, when necessary, to reflect better understanding of the job as it unfolds, work-arounds to problems and changes in scope or direction- which in this day of fixed price projects can't be tolerated to any significant degree. Key to success is achieving and maintaining a clearly understood project objective up front with the customer.

On Pathfinder, for Project performance tracking and control, we adapted the hair-raising, at times frustrating, two-minute drill "bend but don't break" defensive tactic NFL teams use to protect a lead: give up yardage but don't let them score. You start the project, this defensive drill, with sufficient dollars and schedule reserves: our available yardage. As mentioned, we started with $50M of the $150M as reserves and laid out a schedule which had deliveries of the major flight subsystems starting as early as 21 months after Project start to provide ample time, 18 months for Flight System Assembly, Test and Launch Operations (ATLO).

[1] Red Hat = Devil's advocates which challenge and question EDL design and test approaches

Proceeding throughout Project development, monthly technical schedule and cost performance measurements are made. - actuals compared against p] an. Plans are updated wi(h both schedule and cost reserves passed out if necessary for recovery against problems- bending but not breaking each month as wc proceed to launch, using wisely our re.serves but not exceeding the caps. Again, important to this is a thorough job of pre-project planning in defining project scope and achieving a thorough Work Breakdown Structure (WBS) and cost estimates.

Emphasis is placed on looking forward towards completion of development, keeping a thorough cost-to-complete estimate for all development items:

The cost to complete estimate is equal to actual dol lars expended to date plus dollar reserves required for delayed work and problems- present problems plus an estimate for the likel y set of fut ure probl ems: "what ifs".

This is in contrast to management's tendency to look backward in measuring a project's performance: measuring actual accomplishments against the original base.line. plan, but this too is important. This is where computer aided project metrics are handy: producing quickly, modified plans and forward looking cost-to-complete est i mates for the Project, at the same time comparing Project performance against the original baseline plan for its management. '

On Pathfinder we have an excellent team!

'J'bird: The discipline of accomplishing effective programmatic and mission risk assessment and mitigation must be initiate.(i in project planning and carried out throughout project development and flight operat ions.

AN 1 MPORTANT PROCESS

On Mars Pathfinder, wc quickl y realized that an important process pervaded both programmatic and mission assessment and mitigation which brought to bear today's expertise and space lessons of my individual team members at the grassroots level. Even though wc are driven to effect new ways of doing business, this concept turned out to be not new, but just as important in the past as it is now.

It boils down to this:

For tasks related to the above implementation steps such as constructing a cost estimate, or assessing $ or schedule reserves needs, or assessing mission risk, the first step is to develop a thorough breakdown of the task into its pieces, i.e., generating a detailed Work Breakdown Structure (WBS) for the budget and generating a breakdown of the mission functions form launch, through cruise, EDL and surface operations. Next, each piece of the task is given to an acknowledged expert of that piece for analysis. In most cases this is a project team member empowered to implement this piece, but it could involve. also one. or two of his/her peers in support.

Infusing expertise and lessons learned at the lowest levels

You rely on these expert's past experience base with their space lessons learned scars coupled with their knowledge of present technologies and methods to derive plans and schedules for cost estimates and for assessing weak and strong points of design for reliability estimate.s in Mission Risk Assessment. This is risk analysis coming in at the lowest level, early when it counts.

once all the pieces of the task are analyzed, then they are added to form a cost estimate, say, or they are inputted into a Monte Carlo process to dc.rive. a Mission Success probability for Risk Assessment, as another example. In folding in the pieces, relative. "weak pieces" are identified for corrective action to make them better.

A conscious and thorough applicat ion of this process described above is bui It i nto the Mars Path fi nder approach, it's almost automatic. Again, nothing here is new - but it's surprising as to how many places this same process is useful. Also, it's in the quality of the execution of this process that counts and this takes an excellent team, knowledgeable and respect ful of past space lessons learned.

Global/top down infusion of space lessons.!ulu]c(l

in addition, Mars Pathfinder, conducts external peer reviews periodically of all key design, implementation and test decisions made by the project, over 75 of these to date.

For Mars Pathfinder's Risk Assessment and Mitigation activity, past deep space mission[2] failures, problems and also successes are being scrutinized for "common threads" of mistakes, oversight and deficiencies and for things that went right that Mars Pathfinder can avoid or exploit.

[2] Mariner, Viking, Voyager, Magellan, Gallileo, Mars Observer missions

Bottom line on mission risk: **Robust designs, adequate margins, extensive flight qualification and testing, limited critical redundancy, built-in graceful degradation, coupled with a short mission life are our major mission risk mitigations.**

STATUS ON OUR 1'11S11 TO LAUNCH

CY95 was our year for extensive EDL simulations and testing, around **50,** many were drop tests from towers or helicopters. A sampling of these include:

1. RAD rocket fire drop-tests at china] Lake, California in February and December
2. Airbag drop tests at NASA's Lewis Research Center Plum Brook facility in May, July and September. Final flight acceptance testing will occur in March and April of this year
3. Airbag retraction/lander uprighting tests in October/November
4. Multi-body, parachute-backsh ell-bridle-lan der in August in a desert outside Boise, Idaho
5. Mortar fire parachute deployment and drop tests in September outside Hoist
6. Altimeter drop tests at China Lake throughout the summer and fall
7. Bridle deploy tests in the summer at China Lake and JPL
8. Aeroshell, cruise stage, lander separation tests in the spring, summer and fall

Most of EDL simulations and testing are complete. We are running our final EDL system Monte Carlo simulations in March and in addition to the airbags, we will complete flight acceptance testing for the bridle and RAD rockets by July, finishing EDL readiness for flight. The flight aeroshell, parachute, airbags and RAD rockets are installed on the flight system at ETR in September. Flight-like items of these are used in flight system environmental and system tests in Pasadena.

In addition, in 1 995, as forecast at project start, we started flight system assembly, test and launch operations (ATLO) on June 1. In Phase 1 from June through December, we conducted initial integration and test of all flight subsystems including the rover and instruments, conducted vibration and centrifuge testing of our electronic box which contains most of the RF and digital electronics, and ran System Tests 1 and 2 focusing on launch, cruise and EDL, but accomplishing some surface operations as well, in February, we complete final spacecraft assembly, nesting and stacking: placing the rover on its pane], folding the lander panels, placing the lander inside the backshell, capping it with the aeroshell and attaching the cruise stage. System Test 3 follows repc.sting System Tests 1 and 2, which were done in a "2-dimensional" configuration using jumper cables, in the final flight configuration. '1'hen, in March and April in our launch/cruise configuration, we do an acoustic test of the flight system followed by solar thermal/vacuum, STV- 1. System Test 4 follows STV- 1 emphasizing surface operations, prior to a second thermal/vacuum, STV-2, in June, but this time not quite vacuum, but at Mars atmospheric pressure with the lander and rover in their surface operations configurations. Following STV-2, we do our final System Test 5 in August in Pasadena before shipment to ETR in August- a thorough test of all launch, cruise, EDL and surface operations functions.

At ETR, we repeat elements of the Pasadena System Test 5, final assembl y, final spin balance tests in both the cruise and entry configurations, pyro arming, fueling, launch vehicle mate, and launch!

Unlike NEAR, our launch dots not happen at a convenient time in the day, but at 2 a.m. Eastern Standard Time. Before the fins] all-up countdown simulation with everybody at their stations, the project will practice this event at least 3 times by themselves- at our launch time. Hopefully our launch will go as well as the NEAR launch. Figures 3, 4 and 5 depict the lander, its cruise stage and the I-over.

Table 2: ACRONYM LIST

APXS = Alpha, Proton, X-Ray Spectrometer
ASI/MET = Atmospheric Structure Instrument/Meteorology
ATLO = Assembly, Test and Launch Operations
BIP = Backshell Interface Plate
CIT = California Institute of Technology
EDL = Entry, Descent and Landing
ETR = Eastern Test Range
HGA = High-Gain Antenna
IMP = Imager for Mars Pathfinder
ISA = Insulated Structure Assembly
LGA = Low-Gain Antenna
RAD = Rocket Assisted Deceleration
TPS = Thermal Protection System
UCLA = University of California, Los Angeles
UHF = Ultra High Frequency
USC = University of Southern California

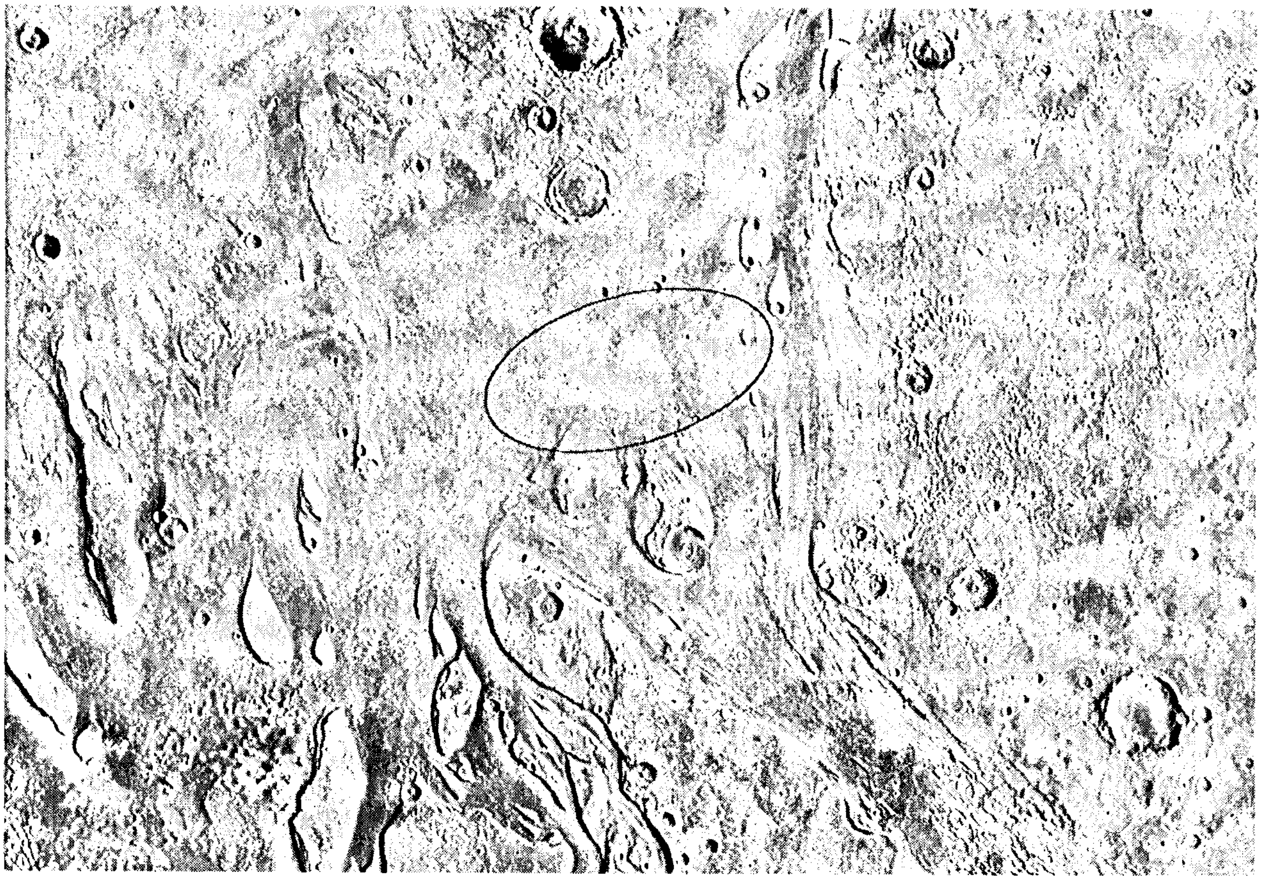

Figure 1: MARS PATHFINDER LANDING SITE

Regional mosaic showing the Mars Pathfinder landing site (100 km by 200 km landing ellipse. shown). The mosaic shows large catastrophic outflow channels debouching from the southern heavily cratered highlands into Chryse Planitia and the northern lowland plains. Ares Vallis flowed to the northwest (from the southeast) across the landing site. Tiu Valles, just to the west of Ares Vallis, probably also flowed across the landing area. The landing site itself is a very smooth depositional surface, where the flood waters deposited the sediments carved from the channels. Landing at this location should allow analysis of a wide variety of rock types deposited by the flood.

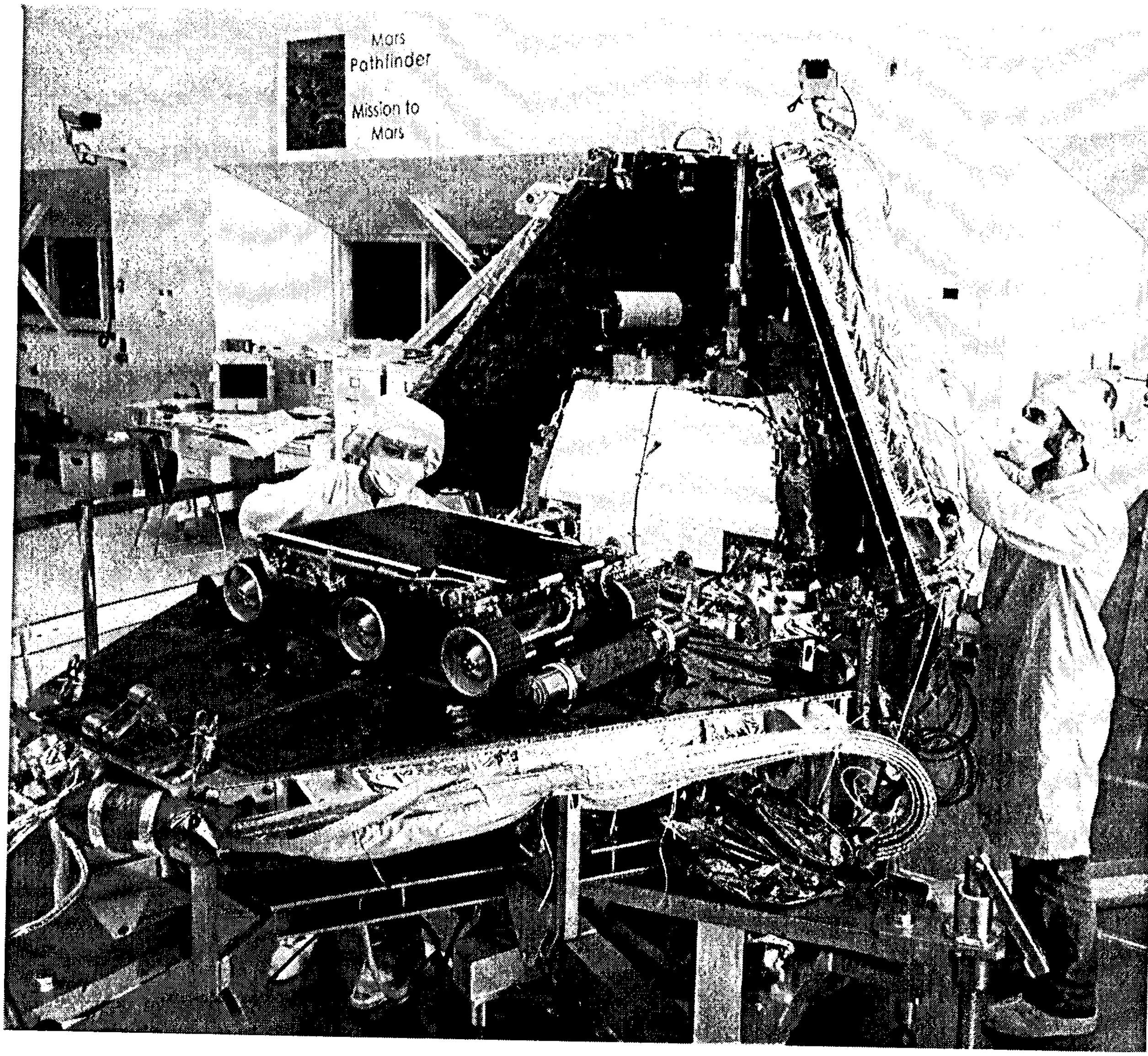

Figure 2: MARS PATHFINDER LANDER

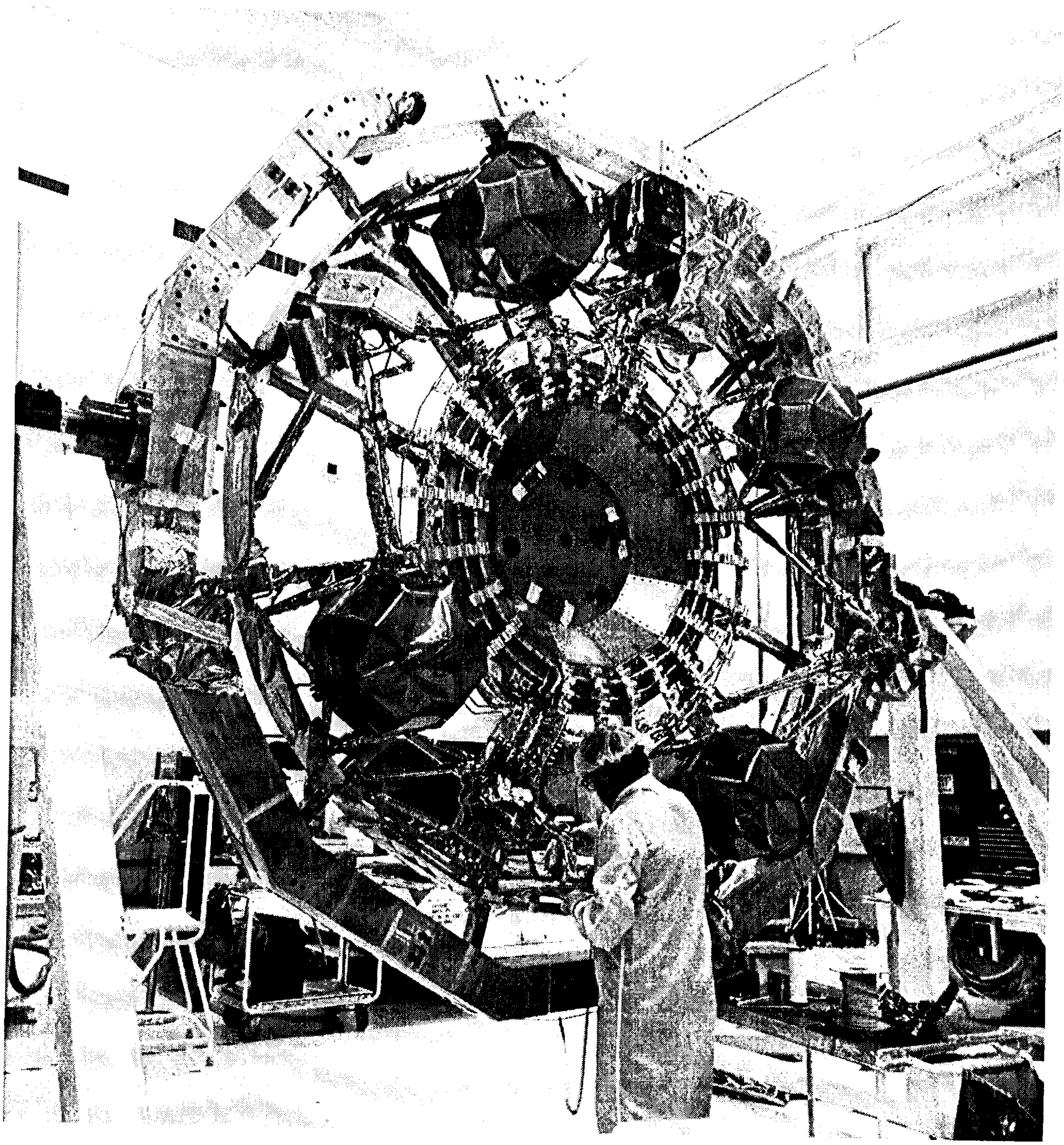

Figure 3: MARS PATHFINDER CRUISE STAGE

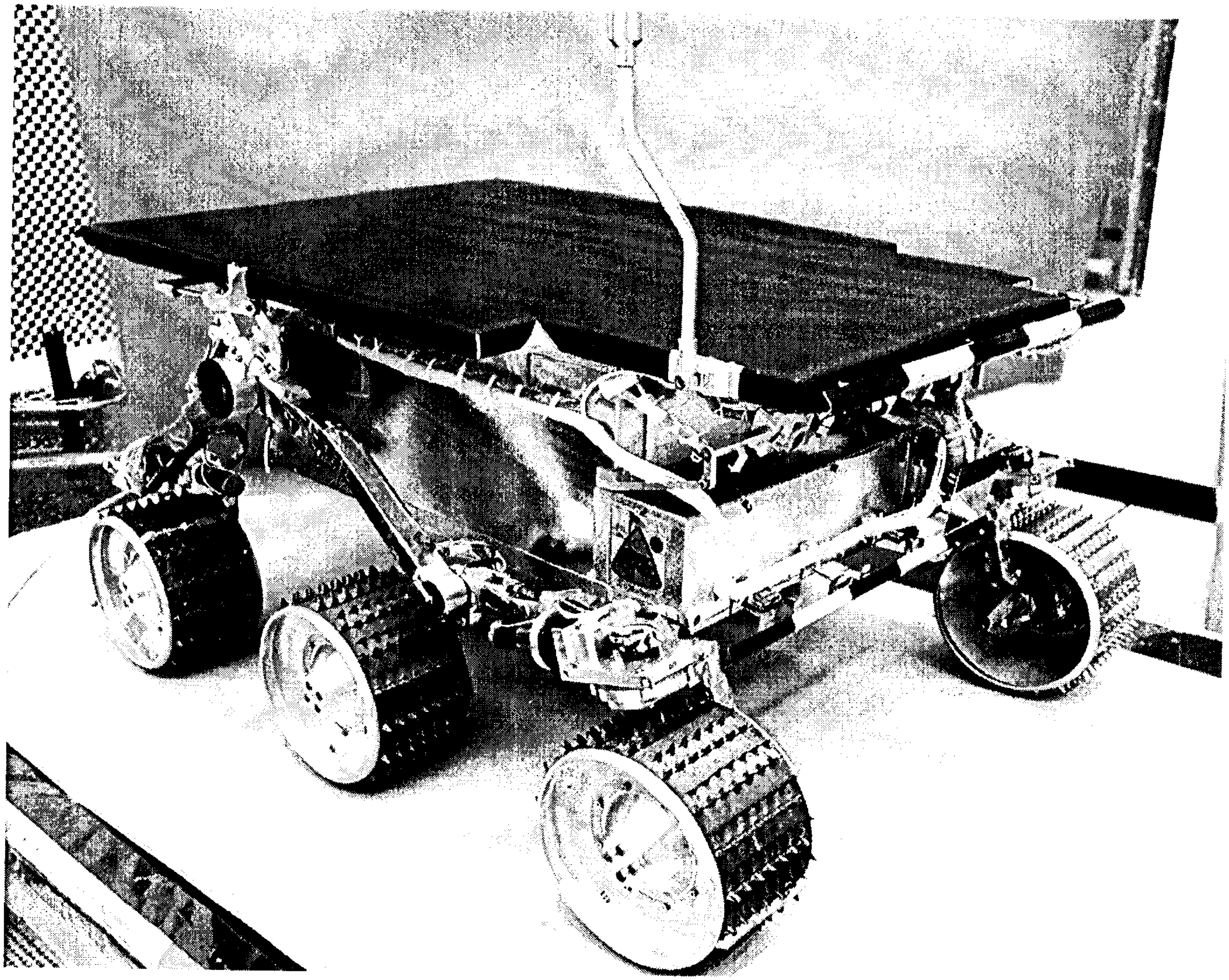

Figure 4: MARS PATHFINDER ROVER